




Regional Patterns and Drivers of the EU Digital Economy

Monica Răileanu Szeles^{1,3} · Mihaela Simionescu^{2,3} 

Accepted: 3 February 2020 / Published online: 10 February 2020
© Springer Nature B.V. 2020

Abstract

This paper examines the progress made by the EU regions on the path of digitalisation and growth of digital economy, by analysing the dynamics and drivers of a selected number of specific indicators, based on Eurostat data running from 2001 to 2016. The study is conducted at regional level, and finally aims to identify policy measures that could enhance the growth of digital economy in the EU area. Moreover, the paper investigates whether a common set of economic and social policy measures is effective in improving several indicators of digital economy, in the New Member States (NMS) as well as in the Old Member States (OMS), given that they still exhibit different patterns of digital transformation at regional level. The increase in tertiary education attainments together with the increase in the number of issued patents are found to be policy measures that generate positive effects for several indicators of digital economy, as well as for the NMS and OMS.

Keywords Digital economy · Digital divide · Economic growth · Patents

JEL Classification O11 · O30 · R58

1 Introduction

The digital technologies have been transforming the national economies all over the world. They continuously evolve and expand into more and more parts of the economy and society, opening the doors toward a new economy—the smart, data-driven and learning economy (Hanna 2016).

Although the empirical evidence suggests that the digital sector is less than 10% of most economies when being measured by value added, income or employment (IMF 2018), the modern economy is in a broad sense a “digital economy” since digitalization is part of almost all economic activities. The policy makers’ ability and motivation to harness the digital revolution for economic development vary from one country to another, so that the technological advance and digitalization differently impact regional and national

✉ Mihaela Simionescu
mihaela_mb1@yahoo.com

¹ Transilvania University of Brasov, Brasov, Romania

² University of Social Sciences, Lodz, Poland

³ Institute for Economic Forecasting of the Romanian Academy, Bucharest, Romania

economies (Hanna 2016). All EU countries are embarked on the road of digital economy, but important gaps still exist between them. The digital transformation is at the core of this new economy whose biggest challenge is to largely and equitably ensure developmental payoffs. But this digital transformation goes much beyond developing advanced digital technologies. It equally requests investing in institutions and effective economic policies because otherwise, despite the widespread use of the Internet, the benefits from digitalization will be rather isolated. A number of strategic frameworks have been recently advanced to facilitate the construction of the digital transformation ecosystems (Hanna and Knight 2012; Hanna 2016). Common interdependent components of the ecosystems discussed in the literature are: policies and institutions; human capital; ICT services sector; ICT infrastructure; and digital transformation applications.

The Digital Agenda for Europe was launched in 2010 with the primary aim to boost Europe's economy by delivering sustainable economic and social benefits from a digital single market. Since then, a number of initiatives were taken by the European Commission and other European institutions, as well as by regional and local authorities, to support the development of the Digital Single Market and to finally help Europe's citizens and businesses to get the most out of digital technologies (EU 2014). For instance, in 2015 the European Commission launched the Digital Economy and Society Index for the EU Member Countries, as an online tool to measure the progress toward a digital economy and society as well as the digital divide across the EU on an annual basis.

Even though most European initiatives in the area of digitalization aims at developing the Digital Single Market by addressing priorities at national level, the digital strategies undertaken at *local and regional level* are equally important for the citizens' well-being and economic growth. However, there is a number of challenges still to be overcome at regional level, including the lack of personnel with ICT skills, poor broadband connectivity, and regional gaps in the use of new technologies (Margaras 2018). At both the regional and national level, the digital divide still exists across the EU with regard to connectivity, human capital, use of internet, integration of digital technologies by businesses, and digital public services (Răileanu Szeles 2018; Margaras 2018).

This paper comparatively examines the effects of a number of governmental policy measures on a set of digital economy indicators, in order to find out whether their effects are positive and consistent across indicators, as well as across the New Member States (NMS) and Old Member States (OMS). The policy measures analysed in the paper are selected as to be in line with the digital transformation ecosystem proposed by Hanna (2016), while the indicators of digital economy are chosen upon the digital economy metrics introduced by Kotarba (2018).

Although the concept of "regional digital economy" has been identified by several national and international organization and occasionally referred to as in reports and strategies (e.g. The River Valley Regional Commission, Digital Economy Strategy for Melbourne's North, SAMENA Telecommunications Council, Association of South-east Asian Nations etc.), upon our knowledge it has not been addressed so far by research papers. Only the regional digital divide in the European Union has been approached in the literature, which is still scarce in this research area, being represented just by three papers (Vincente and Lopez 2011; Garcia et al. 2014; Raileanu Szeles 2018). However, their scope and objectives are different. Vincente and Lopez (2011) measure and analyse the regional disparities in comparison with the income gap in the EU, while Garcia et al. (2014) explore the factors behind broadband expansion at the regional and national level by a multilevel analysis. Both papers are in fact cross-sectional studies focusing on a single point in time. Răileanu Szeles (2018) uses a multilevel approach to investigate the EU regional divide by

both regional and national factors. In addition to the empirical evidence brought by these three studies, this paper focuses on the “regional digital economy”, and frame this concept into the regional data provided by Eurostat. It therefore fills a gap in the literature because it gives insights, for the first time, into the drivers and policy measures enhancing the regional digital economy in the EU. In this light, the paper could provide empirical insights for the operationalization of the EU digital economy, being therefore useful for the implementation of Digital Agenda for Europe.

Another innovative contribution of the paper consists in analysing the differences between the digital economy indicators in the NMS and OMS at regional level. This paper is built on the hypothesis that different determinants explain the development of the regional digital economy in the NMS and OMS. Moreover, an overall analysis of the determinants at the EU-27 level is performed. This approach is new in the literature on European digital economy.

The paper is structured in 4 sections. The first section, which is the Introduction, is followed in Sect. 2 by a short review of the literature. The authors present the methods and data in Sect. 3, while Sect. 4 is the empirical analysis. Section 4 concludes and addresses a set of policy recommendations based on the empirical results.

2 Literature review

Over time, an extensive literature has developed around the concepts of digitalisation and digital economy, but despite their old roots dating back to the years 1997,¹ the related regional aspects remain only briefly addressed in the literature. However, there is no agreed definitions of the digital sector, digital products or digital transactions (IMF 2018), so that the conceptualization of digital economy ranges from activities based on online platforms, to activities that use digitized data.

This ambiguous definition of digital economy leads among others to inconsistent estimates of the size of digital economy (Ostrom et al. 2016). Various indicators have been used to conceptualize and operationalize the technological progress beyond the digital economy and digitalization. Initially, the digital economy was defined as an economic system characterized by a widely use of ICT's, embracing the base infrastructure, e-business and e-commerce. Over time, its scope has widen at the same pace as the development and evolution of digital technologies, so that the digital density index launched in 2015 comprises at present 50 indicators grouped in 4 activity areas and 18 groups of metrics (Macchi et al. 2015). In 2016, the Digital Economy and Society Index (DESI) was created in the framework of the Europe 2020 Strategy as to capture the performances of the EU Member States in digital competitiveness. At present, depending on the definition, the size of digital economy is considered to range from 4.5 to 15.5% of world GDP (UNCTAD 2019).

Over time, a large number of studies have examined the main drivers, dimensions and indicators of digital economy, by focusing on certain dimensions of digital economy, and using especially cross-country analyses. The electronic commerce, Internet usage and human resources in ICT are among the variables usually used to operationalize digital economy, being also included in the most popular indexes of digital economy, such as DESI. This consideration, along with the availability of the three indicators in the Eurostat

¹ The concept of digital economy first mentioned by Don Tapscott in his publication (Tapscott 1997).

dataset, were the main reasons that guided our decision to include them in our empirical study. We briefly present below the most important contributions to the literature with regard to the determinants of electronic commerce, Internet usage and human resources in ICT.

Previous studies on electronic commerce conducted at the level of small and medium enterprises are focused *inter alia* on E-readiness (Molla and Licker 2005; Ramayah et al. 2005; Raven et al. 2007; Fathian et al. 2008; Anton 2010), electronic commerce adoption (Lawson et al. 2003; Jeon et al. 2006; Kartiwi and MacGregor 2007; Choshin and Ghaffari 2017), electronic commerce diffusion (Beck et al. 2005a, b; Raymond et al. 2005; Mohamad and Ismail 2009), and consequences of electronic commerce (Beck et al. 2005a, b; Raymond et al. 2005; Fisher et al. 2007; Teo and Pian 2003; Drumea 2015; Anvari and Norouzi 2016).

In the literature of the electronic commerce adoption and diffusion most papers examine microeconomic factors, such as the anticipated benefits, the variety of tasks inside the firm, as well as the organizational culture (Seyal et al. 2004). The adoption of electronic commerce by US small and medium companies is explained by Grandon and Pearson (2004) through four microeconomic factors, i.e. the perceived ease of use, anticipated usefulness, external pressure and organizational readiness, which allow companies getting higher profits and also providing higher salaries to their employees. The costumers demand and satisfaction, the pressure of competition, the amount of costs and infrastructures, and knowledge and information are found to be the effective's factors which have a significant impact on e-commerce success (Choshin and Ghaffari 2017). The size of company is also found to be a significant microeconomic driver of electronic commerce. Compared to small and medium firms, large firms are more likely to use electronic commerce (Sharma et al. 2004; Burke 2005), because they have lower technology capabilities and fewer resources (Thong 2001). However, the resource constraints are generally surpassed by the simple structures of smaller firms that ensure a better adaptation to different changes in the company environment (Al-Qirim 2004).

Another stream of literature investigates the consequences of electronic commerce. The improvement in internal operations, the inter-organizational connectivity (Mohamad and Ismail 2009), as well as the efficiency improvement, cost reduction, the extension of market potential and the acquiring of new business opportunities (Beck et al. 2005a, b; Fink and Disterer 2006; Song et al. 2017) are found to be among the most important benefits induced by the use of electronic commerce at microeconomic level. For sellers, the benefits of electronic commerce consists of lower costs, streamlined supply chains, easy access to new markets, more revenue streams and more clients stickiness (Kasiri et al. 2017), while the customers' advantages reflect in innovative services and products, new and faster shopping experiences, and entertainment (Pappas et al. 2017).

At the macroeconomic level, all benefits induced by the adoption and diffusion of e-commerce increase profits for firms, and in the same time they lead to economic growth and economic development (Anvari and Norouzi 2016; Digital Economy Report 2019; Dimitrova 2002; Dimitrova and Beilock 2005). However, the electronic commerce adoption and diffusion are generally separately addressed in the literature.

According to Mohamad and Ismail (2009), the adoption of electronic commerce is conditioned by a set of macroeconomic factors, as follows:

- Individual factors (IT knowledge, characteristics of management, management support);
- Organizational factors (type of industry, company's size, costs, digital skills);

- Environmental factors (government support, external expertise support, technological infrastructure, network intensity, communication channel, business location, pressures made by clients or business partners);
- Technological factors (relative advantage, perceived usefulness, compatibility).

The classification above doesn't consider other significant economic factors, such as the export intensity, international market intensity (Kula and Tatoglu 2003; Chong 2008), or the country's welfare measured by the GDP per capita (Wang and Liu 2015).

Apart from the empirical insights above, it has been also found that the electronic commerce adoption is influenced by the countries' economic development in the sense that the developing countries adopt the electronic commerce at a slower pace than the developed ones (Migiro 2006). In contrast, the organizational factors represent the main barrier for adopting the electronic commerce in developing countries, while technological impediments seem to be specific especially to the developed countries (Kartiwi and MacGregor 2007).

The electronic commerce diffusion is found to have different correlates than the electronic commerce adoption. The technologies used by firms (Al-Qirim 2007) as well as the business functions, such as communication, interaction, transaction (Raymond et al. 2005), are the main drivers of the electronic commerce diffusion. However, there are also social and economic factors that influence the electronic commerce diffusion and are not related to firms, but to their clients, i.e. the country's welfare measured by GDP per capita (Wang and Liu 2015), poverty (Safavi 2009), fertility (Zotta et al. 2000), life expectancy (Olphert and Damodaran 2013), education and medical services (Pick and Nishida 2015). Our paper follows this line of research. Recently, the advance of wireless technology and the digital transformation have provided new opportunities for the development of mobile e-commerce (Dulloo and Rajeswari 2018).

In contrast to electronic commerce, which reflects the application of ICT in business and commerce, the Internet usage is a core indicator of the ICT usage by businesses, households and individuals (United Nations 2005). When studying the Internet usage at the company level, the firm's size is found to be one of the most important determinants. Small business managers use implicit managerial perceptions to take strategic decisions (Day 1994; Caniels et al. 2015), but large companies are more eager to use Internet resources in the decisional process (Carson 1993).

The Internet usage is also explained in relation to the market orientation business approach. The model proposed by Celuch et al. (2007) combines market orientation (Internet efficacy, Internet usage benefits) and behavioural norms (behavioural intentions) to explain the Internet usage. Market orientation focuses on meeting the needs of its customers, based on data related to clients and their needs, competitors, suppliers and government regulations (Narver and Slater 1990). A strong market orientation requests the intensive use of Internet which allows gathering information about customers and competitors' behaviours.

At the level of individual, the Internet usage is explained based on personality traits (Hamburger and Ben-Artzi 2000; Armstrong et al. 2000; Scealy et al. 2002; Leung 2002). For example, Internet usage was positively correlated to shyness (Scealy et al. 2002), self-disclosure (Leung 2002), low-esteem (Armstrong et al. 2000), and neuroticism and extraversion (Hamburger and Ben-Artzi 2000; Landers and Lounsbury 2006). Beside intrinsic reasons related to the confidence in technology, there are also economic and demographic factors that condition the use of Internet.

Internet usage is positively correlated to income, given that a higher income allows buying more easily Internet access devices and paying for ongoing access. This also means that lower income consumers are discouraged to access high quality Internet (Schultz 2005).

At the macroeconomic level, the income per capita is among the most important determinants of the Internet usage. Countries with higher income per capita also have higher rates of Internet penetration (Elie 1998; Arnum and Conti 1998; Hargittai 1999; Beilock and Dimitrova 2003). The higher Internet penetration in the developed countries is due to the developed infrastructure, which also reflects advanced telecommunications (Bazar and Boalch 1997; Maherzi 1997). In turn, the income concentration measured by the Gini coefficient has an insignificant effect on Internet usage (Hargittai 1999). Other drivers of the Internet usage are the legal and political conditions (Wolcott et al. 2001), the expenditure on R&D (Nelson 1993), and the employment status. Campos et al. (2017) finds that the employed people are more likely to use the Internet, especially at work, in comparison with the unemployed. Moreover, Blank and Groselj (2014) explain that the employment status, age and education influence the Internet diffusion.

The relationship between economic growth and the Internet usage is closely related to the relationship economic growth—ICT usage, the latter being the subject of mixed empirical findings. While most papers find a clear positive relationship (e.g. Niebel 2018), others find rather a modest positive association between ICT and growth, and no significant evidence that the Internet has had a positive impact on growth (Stanley et al. 2018). However, there is another part of the literature which examines the bidirectional relationship from ICT to economic growth (e.g. Hong 2017; Saidi et al. 2018).

The impact of age on the decision to use the Internet has been extensively analysed in the literature. Older people prefer to develop relationships in order to satisfy their emotional goals (Cartensten 1995), while younger people prefer to get information quickly using Internet rather to emotionally involve in a relationship (Porter and Donthu 2006). Moreover, many seniors prefer to achieve their emotional goals within smaller groups of people (Charles and Carstensen 1999), while younger individuals connect more easily with a large network of individuals using the Internet. People with higher education are more eager to use the Internet compared to the less educated ones, since innovation creates homophilous groups with higher social and economic status (Rogers 2010).

The profile of the Internet users has dramatically changed over time. While in the '90 the American internet users were well-educated, mostly males, and had upper incomes (NTIA 1999; Mendoza and Alvarez de Toledo 1997; Dimitrova et al. 2001, 2005), at present older people with lower education and women also access the Internet. Even though the digital gap has decreased over time, it still exists, e.g. the education-related digital divide (Cruz Jesus et al. 2016), as well as the grey digital divide (Friemel 2016).

Another body of literature examines the impact of government policies on the Internet diffusion. Guillén and Suárez (2001) explain that the predictability of policymaking is a relevant determinant for the inter-country Internet diffusion. Billon et al. (2017) analyse a sample of 90 developed countries running from 1995 to 2010, and find that public policies and the quality of human capital represent key determinants of the Internet usage. Press et al. (1998) explain the Internet diffusion by a mix of 5 factors which also reflect the effectiveness of public policies: geographic dispersion within the country, connectivity infrastructure, sectorial absorption, pervasiveness, organizational infrastructure, and sophistication of Internet use. Scheerder et al. (2017), provide a systematic classification of the common drivers of the Internet usage and electronic commerce.

The employment in the HT sector represents another indicator in the area of digital economy, which has been analysed at a lesser extent in the literature, in comparison

with the digital divide indicators. Acs et al. (1999) examine 36 US cities and show that the employment in the HT sector is primarily influenced by the university R&D. Other studies confirm the central role played by universities in stimulating the development of new technology and ensuring high-skilled graduates (Segal 1995; Agrawal and Cockburg 2003).

The companies' location near or in large urban centres with a higher capacity to innovate than the rural areas represents another determinant of the employment in HT (Duguleana et al. 2017). For instance, Holm and Østergaard (2015) analyse a number of Danish regions and find that the smaller HT companies adapt easier to economic shocks (e.g. economic crises) compared to the large companies. These findings lead to the conclusion that the size of HT companies, as well as their location, carry a significant impact on the employment in HT.

For developing countries, Schmitz (2018) explains that people are interesting to work in HT especially because of the wages and employment conditions provided by the companies acting in this sector. But most jobs in HT require a higher level of education (Piva and Vivarelli 2017), and the fast dynamic of changes occurring in this sector force employees to keep up with the technological progress, eventually by long-life learning programmes. In turn, the higher, the higher wages and the organizational support wages provided in this sector represents a key motivation for employees (Ertürk and Vurgun 2015).

3 Method and data

3.1 Data

The analysis is carried out at the EU regional level, based on Eurostat data running from 2001 to 2016. According to the NUTS classifications, the EU Member States are divided into NUTS 1 regions, which in turn are subdivided in NUTS 2 regions, and then divided in NUTS 3 regions. At the 1961 Brussels Conference on Regional Economies, organised by the Commission, the NUTS 2 regions have been acknowledged as being the framework generally used by Member States to apply their regional policies. In present they are defined as “basic regions”, being used for the analysis of regional and national problems. This paper uses data aggregated at the NUTS 2 regional level, not only because our research objective is to examine the EU regional digital economy, but also because this kind of data allows us formulating policy recommendations at the EU regional level which could provide valuable insights for the EU policy.

The selection of variables to describe digital economy in our empirical study is based on the Eurostat data availability, where two categories of regional indicators, i.e. “Regional science and technology statistics” and “Regional digital economy and society” group together all relevant variables at the NUTS 2 level of aggregation. As stated by Eurostat, they reflect the progress in the development of the EU regional digital economy. The indicators of digital economy which enter into our regression models as dependent variables are not only selected from the categories above, but they are also chosen as to be representative for the activity areas summarized by the Digital Economy and Society Index, i.e. (1) human capital, (2) use of internet, and (3) integration of ICT, according to the data availability in Eurostat at the NUTS 2 level. They are:

1. “Individuals who ordered goods or services over the Internet for private use in the last year” (abbreviated “electronic commerce”) which belongs to the area of Integration of information technologies and reflects the third-order digital divide;
2. “Individuals regularly using the Internet” (abbreviated “Internet usage”), which gives insights to the Internet usage and second-order Internet divide;
3. “Employment in HT sector” (abbreviated HT employment”), which represents here the human capital.

Our selection of dependant variables is grounded in the literature on ICT and digital economy. As a proxy for IT skills (Goss and Phillips 2002), the rate of Internet usage in a region represents a driver for location of ICT companies in that region (Giner et al. 2016). Also, it reflects the activities performed by citizens on-line. The number of employers in HT sector reflects the extension of the ICT sector in a specific region. In addition, it represents an indicator of the advanced skills that empower the workforce to take advantage of technology (Kotarba 2018). The usage of electronic commerce into a region gives insights in the digitization of businesses, which allows businesses enhancing efficiency and reducing costs. As the development of ICT infrastructure represents a pre-condition for the e-commerce growth (Kumar et al. 2014), the latter could act as a catalyst for the growth of the high-tech industry.

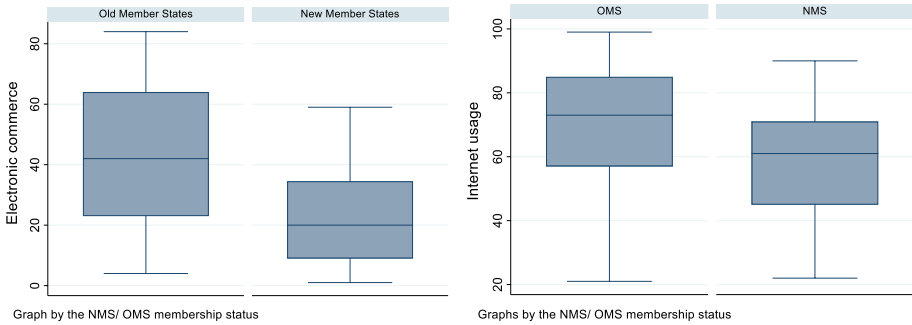
The indicators of digital economy are explain upon a set of independent variables (aggregated at the NUTS2 level) which reflect several dimensions of economic development, as presented below:

- Economic development: “GDP per capita”;
- Productive or main activity: “Unemployment”;
- Education: “Tertiary educational attainment” (abbreviated “Tertiary”) and “Secondary educational attainment” (abbreviated “Secondary”);
- Poverty: At risk of poverty rate (abbreviated poverty);
- Health: “Number of physicians or doctors per 100.000 inhabitants” (abbreviated Doctors”);
- R&D expenditure: “High-tech patent applications to the European patent office (EPO) per million inhabitants” (abbreviated “Patents”);
- Demographic dimension: “Fertility”, “Life expectancy”, “Pupils and students in all levels of education” (abbreviated “pupils”).

The descriptive statistics reported in Table 1 give insights to the differences between the NMS and OMS with regard to the development of ICT sector and digital economy. The largest disparities are in the area of electronic commerce, while the differences in terms of HT employment are rather insignificant between OMS and NMS. The heterogeneity within the OMS is the highest for electronic commerce, while for the Internet usage the dispersion is almost similar in the NMS and OMS. The largest differences between NMS and OMS in terms of minimum and maximum values are still for the electronic commerce. These results indicate that, in spite of the progress made by the EU countries in closing the ICT gaps, important differences still exist in the area of electronic commerce. These gaps hinder the achievement of the Single Digital Market and the growth of the EU regional digital economy.

Table 1 Descriptive statistics, 2001–2016

Descriptive statistics	Electronic commerce	Internet usage	HT employment
Mean			
NMS	22.44	57.78	3.39
OMS	43.4	70.22	3.99
SD			
NMS	14.98	15.60	1.86
OMS	21.91	17.98	1.85
Minim			
NMS	1	22	0.6
OMS	4	21	0.5
Maxim			
NMS	59	90	9.5
OMS	84	99	12.8

**Fig. 1** Box plots of Internet usage and Electronic commerce, upon the NMS/OMS status

In Fig. 1 above, the Internet usage and Electronic commerce in NMS and OMS are represented by box plots in order to underline the significant differences between NMS and OMS in the area of digital divide, and to therefore justify the decision to separately conduct most regression models for NMS and OMS in the empirical section. As expected, the differences between NMS and OMS are even larger in the case of Electronic commerce especially when looking at the medians and higher/maximum values of the two distributions. The discrepancies between NMS and OMS are not surprising because, according to the literature, the Internet usage, as a form of two-order digital divide (Van Dijk and Hacker 2003), represents a basic condition for the wide spread of Electronic commerce, which is a form of third-order digital divide (Robles et al. 2011), so that the proportion of population using the Internet is higher than the proportion of population being Electronic commerce users.

3.2 Method

The main drivers of the regional digital economy within the EU-27, NMS and OMS, from 2001 to 2016 are examined by a set of dynamic panel data regression models,

using Eurostat data. Compared to cross-sectional regression, panel regression allows analysing the dynamic of change, which could reveal in this particular case the drivers behind the transition to digital economy within the EU area. In addition, panel data allow controlling for individual heterogeneity, offer more variability, less collinearity among the dependent variables, more degrees of freedom and more efficiency in estimation (Baltagi 2014). All these aspects provide a comprehensive area for the analysis of the EU digital economy.

According to the methodology of panel regression models, the testing of regression assumptions will precede the regression analysis. First, heteroskedasticity of residuals will be examined by the likelihood ratio tests. In case that the disturbances are found to be heteroscedastic, even though the OLS estimator remains unbiased and consistent, other estimators are more efficient. Additionally, if the error terms are correlated, the OLS remains unbiased, but it is no longer asymptotically efficient. The solution in this case is either to use heteroskedasticity/autocorrelation -robust estimators of the variances, or efficient estimators by re-weighting the data as to take into account the heteroskedasticity/autocorrelation (by using the Feasible Generalized Least Squares estimator- FGLS). But when endogeneity occurs, the OLS and GLS will become inconsistent, and the *finite* sample bias can be substantial for *small* T. The solution to overcome this problem is to use instrumental variable estimators (IV) which are consistent for *finite* T.

In the last 30 years, the GMM estimator has become a popular tool in the panel regression analysis, as well as a useful heuristic tool (Baum et al. 2003). Despite its widely use in empirical studies, the poor finite sample performance has been often addressed as a major drawback of this method (Hayashi 2000). Consequently, if heteroskedasticity is not present in the dataset, then standard IV should be always preferred because in this case the GMM estimator is no worse asymptotically than the IV estimator. Moreover, finding good instrument might be quite challenging in empirical researches. Instruments should be always relevant and valid, i.e. correlated with the endogenous regressors and at the same time orthogonal to the errors. The correlation with the included endogenous variables can be assessed by examining the fit of the first stage regressions. The instrument's independence from an unobservable error process can be tested by the corresponding moment conditions. In the case of GMM, the overidentifying conditions are generally tested by the *J* statistic of Hansen, while in the IV context the Sargan statistics is used instead of *J*.

In the empirical section, the testing for heteroskedasticity, autocorrelation and endogeneity leads to the selection of FGLS and system GMM as estimators of panel regression models.

To sum up, our empirical analysis develops in three steps:

- Testing the linear regression assumptions
- Selecting the appropriate estimators
- Running the regression models and interpreting the regressions output

A number of three dynamic panel regression models will be run in the empirical section, to comparatively analyse the impact of a set of economic, social and demographic variables on the indicators of digital economy. Different estimators and regression equations are used, to accommodate the specificity of each relationship, as well as the results of the linear regression assumptions testing. Preliminary tests have confirmed the presence of endogeneity just in the case of two out of three regression models.

In Eq. (1) the electronic commerce is explained upon a set of endogenous economic, social and demographic variables.

$$y_{it} = \alpha y_{i,t-1} + \beta X_{it} + \varepsilon_{it} \quad (1)$$

$$\varepsilon_{it} = u_i + v_{it} \quad (2)$$

In Eq. (3), both endogenous and exogenous variables are used to explain the internet usage.

$$y_{it} = \alpha y_{i,t-1} + \beta X_{it} + \delta Z_{it} + \varepsilon_{it} \quad (3)$$

$$\varepsilon_{it} = u_i + v_{it} \quad (4)$$

As in Eq. (3), employment in the technology sector is explained in Eq. (5) by both endogenous and exogenous variables.

$$y_{it} = \alpha y_{i,t-1} + \beta X_{it} + \delta Z_{it} + \varepsilon_{it} \quad (5)$$

$$\varepsilon_{it} = u_i + v_{it} \quad (6)$$

where X_{it} is a vector of exogenous regressors, Z_{it} is a vector of endogenous regressors (being correlated with u_i), β and δ are two column vectors of coefficients, and y_{it} and ε_{it} are random variables. The independent variable (y_{it}) is the electronic commerce (in Eq. 1), the internet usage (in Eq. 2) and the employment in the technology sector (in Eq. 3). As shown in Eq. 2, the disturbance term ε_{it} has two orthogonal components: u_i are the fixed effects, and v_{it} are the idiosyncratic shocks.

4 Empirical analysis

The empirical analysis aims to comparatively examine the common and specific economic, social and demographic determinants of the digital economy for the EU-27, as well as separately for the NMS and OMS, based on panel regression models, in order to find out to what extent a common set of policy measures could successfully improve several dimensions of digital economy. As explained in the previous section “Method and data/Data”, three dimensions of the digital economy (i.e. Electronic commerce, Internet usage, and Employment in HT) are analysed by three panel data regression models (models 1, 2 and 3, respectively), and the results are reported in Tables 2, 3, and 4, respectively. Initially, a common set of explanatory variables were examined, but finally, according to the results of the regressions’ tests and specifications, slightly different groups of explanatory variables were included in regressions. However, the explanatory variables are chosen as to be relevant for the policy measures implemented at regional level.

In this section we do not only report and analyse the significance of our empirical findings, but also place them into the strand of existing literature, emphasizing the novelty, conformity or contrasting results.

Preliminary tests are applied to all regression models to guide the models’ identification and construction. As explained in the previous section, the heteroskedasticity, autocorrelation and endogeneity are particularly examined for each model in part, in order to decide which estimator to choose. The heteroskedasticity is examined by simple likelihood ratio tests applied for each regression model, following the methodology presented

Table 2 The determinants of electronic commerce, 2001–2016

Explanatory variables	EU-27 (model 1)	NMS (model 2)	OMS (model 3)
Dependent variable (L1)	0.88*** (0.003)	0.83*** (0.03)	0.87*** (0.005)
Economy			
Log GDP per capita	0.49*** (0.21)	9.11*** (1.06)	−0.19 (0.40)
Unemployment	0.09*** (0.009)	0.19*** (0.06)	0.10*** (0.01)
Demography			
Fertility	2.07*** (0.26)	−1.32 (1.15)	2.44*** (0.34)
Life expectancy	−0.14*** (0.02)	−2.00*** (0.19)	0.11*** (0.04)
Social			
Doctors	−1.62 (0.10)	5.62*** (1.11)	−1.27*** (0.15)
Poverty risk	−0.21*** (0.008)	−0.34*** (0.03)	−0.30*** (0.02)
Education			
Pupils	−0.04** (0.02)	−0.85*** (0.06)	0.003 (0.03)
Tertiary education	0.10*** (0.006)	−0.01 (0.06)	0.09*** (0.007)
Secondary education	−0.07*** (0.005)	0.13*** (0.03)	−0.07*** (0.008)
Patents	0.36*** (0.02)	0.41*** (0.14)	0.33*** (0.04)

(1) Dynamic panel regression model, feasible Generalized Least Squares (FGLS) estimator; (2) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; (3) Eurostat data, 2001–2016; (5) L1 denotes the first lag of the explanatory variable

Table 3 The determinants of Internet usage

Explanatory variables	EU-27 (model 1)	NMS (model 2)	OMS (model 3)
Dependent variable (L1)	0.66*** (0.07)	0.62*** (0.08)	0.93*** (0.04)
Economy			
Log GDP per capita	15.41*** (4.10)	13.81** (6.61)	−11.21*** (4.57)
Unemployment	0.53*** (0.14)	0.62*** (0.20)	−0.04 (0.08)
Demography			
Fertility	8.87*** (2.65)	5.92 (4.25)	5.25** (2.32)
Social			
Doctors	−5.24*** (1.89)	−0.89 (3.78)	1.45* (0.86)
Poverty risk	0.19** (0.07)	−0.01 (0.12)	−0.22*** (0.08)
Education			
Pupils in education	−0.31** (0.15)	−0.40 (0.28)	−0.13 (0.15)
Tertiary education	0.04 (0.04)	−0.11 (0.13)	0.12*** (0.04)
Secondary education	−0.33*** (0.08)	−0.14 (0.17)	0.05 (0.06)

(1) Dynamic panel regression model, Arellano-Bond system GMM estimator; (2) Endogenous variable: GDP per capita, instrumented by its first two lags; (3) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; (4) Eurostat data, 2001–2016; (5) L1 denotes the first lag of the explanatory variable

Table 4 The determinants of employment in HT sectors

Explanatory variables	EU-27	NMS	OMS
Dependent variable (L1)	0.67*** (0.09)	0.47* (0.25)	0.67*** (0.11)
Economy			
Log GDP per capita	3.93*** (1.61)	7.38*** (2.19)	3.35* (2.08)
Log GDP per capita (L1)	-4.77*** (1.46)	-6.66*** (2.52)	-2.96** (1.48)
Demography			
Fertility	-1.01*** (0.40)	0.70 (0.71)	-1.03** (0.43)
Social			
Log doctors (L1)	0.74** (0.39)	-0.24 (0.78)	0.40* (0.24)
Poverty risk (L3)	-0.01 (0.02)	-0.05 (0.08)	0.01 (0.02)
Education			
Log patents (L2)	0.26*** (0.08)	0.21** (0.09)	0.25*** (0.08)
Tertiary education (L4)	0.02*** (0.008)	0.06** (0.02)	0.01** (0.007)
Secondary education	-0.02* (0.01)	0.004 (0.02)	-0.01* (0.008)

(1) Dynamic panel regression model, Arellano-Bond system GMM estimator; (2) Endogenous variable: GDP per capita, instrumented by its first two lags; (3) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; (4) Eurostat data, 2001–2016; (5) L1–L4 denote lags of the explanatory variable

in Wooldridge (2010),² while the presence of autocorrelation is investigated by the Wooldridge test for autocorrelation, upon Drukker's method (2003). The likelihood ratio tests confirm in all three regression models the presence of heteroskedasticity, and the Wooldridge significant test statistics confirm the presence of autocorrelation.

In order to examine the multicollinearity we calculate for each predictor and model the Variance Inflation Factors (VIF), which tell us how much the variance of a coefficient is "inflated" because of linear dependence with other independent variables. As reported in "Appendix", all values are below 6, which indicates that multicollinearity is not a matter of concern here (Hair et al. 1995).

While heteroskedasticity and autocorrelation are found to be present in all three models, endogeneity is found to be a problem of concern only in models 3 and 4, in relation with the variable "GDP per capita". These findings suggest estimating model 2 by the Feasible GLS, while using the system GMM for estimating models 3 and 4.

In Table 2 the electronic commerce is explained upon a set of independent variables in the areas of economy, demography, social issues and education.

The estimates reported in Table 2 indicate that the determinants of the e-commerce adoption are very close when moving across models (1)–(3). Still, there are some differences between them, and they will be explained below.

First, the electronic commerce in the previous year has a significant and positive impact on the e-commerce in the current year, the autoregressive behaviour being a significant measure of the technological progress from 1 year to another in all three models. The GDP

² The rationale of using likelihood ratio tests is finding the presence of heteroskedasticity across panels is that iterated GLS with only heteroskedasticity produces maximum-likelihood parameter estimates. Basically, the test is used here to compare two nested models: the model with panel-level heteroskedasticity, and the model without heteroskedasticity.

per capita represents the most powerful determinant factor of e-commerce in the NMS, while carrying no significant effect in the OMS. Still, the overall effect at the EU-27 level remains significant and positive, as was previously found in the literature (Lund and McGuire 2005; Wang and Liu 2015; Raileanu Szeles 2018).

At the EU-27 regional level, the effect of poverty risk on e-commerce is significant and negative, meaning that a higher poverty rate hampers the adoption of e-commerce. The social factors are identified in the literature among the key factors affecting the growth of e-commerce network (Savafi 2009), and our study confirms this empirical finding.

Fertility is found to be a significant determinant of e-commerce in both EU-27 and OMS. A higher fertility is associated to a higher adoption of e-commerce. Although apparently the two variables seem to not be directly linked one to another, the relationship between them is indirectly explained by the time saving provided by the online shopping. Especially big families, and in general those societies where the fertility rates are generally higher, tend to use more the online shopping to save time (Zotta et al. 2000). Billari et al. (2019) recently find a significant and positive relationship between the fertility rate and broadband internet in Germany. Our empirical findings are therefore in line with previous papers.

The effects of life expectancy on the e-commerce adoption are significant, but different in the NMS and OMS. A higher life expectancy means *inter alia* a higher amount of elderly population, which have on average lower technology and computer skills (Czaja 2016). The difference of our empirical results between the NMS and OMS lies in the fact that in the OMS the digital divide is lower among the elderly than in the NMS (Olphert and Damodaran 2013). At the EU-27 level, as well as in the NMS, a higher life expectancy is associated to a lower use of electronic commerce. In contrast, in the OMS the e-commerce is positively associated to a higher life expectancy, because in the EU developed countries, the ICTs, including smart home technologies and e-commerce, are expected to provide benefits to older adults who would like to remain independent (Peek et al. 2016).

A higher number of physicians or doctors per 100.000 inhabitants represents a powerful determinant factor of the e-commerce adoption in the NMS, while generating a negative effect on the e-commerce adoption in the OMS. As the number of doctors best describes the availability of health care resources, which is however much scarcer in the NMS than in the OMS, this variable could also be seen as an indicator of economic development (Finlay 2007). From another perspective, e-commerce is found to enhance economic development (Lund and McGuire 2005; Anvari and Norouzi 2016). On average, the OMS have higher levels of spending on health as a share of GDP in comparison with the NMS, which further results in more homogenous distributions of health resources at regional level in the OMS (EXPH 2016). As the health care resources are adequate and the unmet health needs are lower in the OMS than in the NMS, the number of doctors is found to be directly linked to the e-commerce adoption, but just in the NMS.

Contrary to our expectations, unemployment is found to enhance the e-commerce adoption under all models (1)–(3). Although in the literature of digital divide the association e-commerce—unemployment has not been directly approached so far, there are studies indicating that when being faced with high unemployment, consumers continue to take advantage of the Internet's lower prices by shifting their spending from offline retail stores, so that e-commerce has become a mainstay in consumer behaviour, driven by the attraction of both lower prices and convenience (Fulgoni 2011).

The number of patents issued in a region determines positive effects on the adoption of e-commerce in both NMS and OMS, as well as at the EU-27 level. This result is according

to our expectations since the number of patents might also be seen as a measure of technological progress with direct impact on economic field and social life.

The positive implications of education on ICT in general and e-commerce adoption in particular have been often examined in the literature (Büchi et al. 2016; Van Deursen et al. 2014; Helsper 2010; Wunnava and Leiter 2009) and the results generally indicate a positive association between education and e-commerce. In Table 2, the tertiary education attainments are found to generate positive effects on e-commerce only in the OMS and EU-27. This is in line with previous papers which indicate that the tertiary education helps bridging digital divide, and in the same time has positive effects on the technology utilization in general (Pick and Nishida 2015).

People holding only secondary education attainments are less open to e-commerce in the EU-27 and OMS. This negative association is explained by the lack of computer and technology skills, which is specific to the low educated people (Litrá 2014). In contrast to the OMS, in the NMS the secondary educational attainments are associated to a higher use of e-commerce. In the NMS, as well as at the EU-27 level, a higher number of pupils and students in all levels of education is associated to a lower use of e-commerce, which is in line with other previous findings (Raileanu Szeles 2018).

In the case of regression models 3 and 4 which are estimated by the system GMM, the output from the Sargan test indicates that the null hypothesis of the exogenous instruments has not been rejected and the joint validity of the instruments is confirmed. The Arellano–Bond test for autocorrelation in the idiosyncratic error states no autocorrelation in null hypothesis. In all models reported in Tables 2, 3 and 4, the test for AR (1) and AR(2) processes in first differences rejects the null hypothesis.

In Table 3 the Internet usage within the EU-27 (model 1), NMS (model 2) and OMS (model 3) is explained upon a set of variables which are very close to those used in Table 2. The small differences between the set of explanatory variables used in Tables 2, 3 and 4 come from the model identification tests.

Even though the estimates of models 1–3 (Table 3) are very close, there are some differences between them. As expected, an autoregressive behaviour is confirmed in all models since the Internet usage become more popular reflecting the technological progress from 1 year to another.

The most powerful determinant of Internet usage in NMS is represented by GDP per capita, while its effect is negative in the OMS. Still, the overall effect at the EU-27 level is positive and statistically significant, according to literature (Guillén and Suárez 2005). The positive correlation between GDP per capita and Internet use might be also explained by the culture of cosmopolitanism in the NMS. The cosmopolitans are defined by Beck (2000) as people who prefer to travel more widely and frequently, have more diverse social contacts and consume more media for arts and internal and foreign affairs. The negative correlation between GDP per capita and Internet use in the OMS might be explained by the local patterns of interpersonal influence on the communication behaviour. In Merton (1957) opinion, these people have more friends in their town or village, travel less frequently and use less media content. Moreover, the people in the developed countries might prefer using mobile phone to communicate which is faster even if it is more expensive than Internet (Guillén and Suárez 2005).

According to our expectations, in the OMS people at higher risk of poverty use the Internet at a lesser extent. This is in line with the literature, as a higher poverty rate is found to hamper the use of Internet (Safavi 2009). However, in the EU-27, even if the poverty risk increases, the Internet use is more intense and widespread. This might be explained by the fast and generalized technological progress that made the use of

Internet cheap and accessible to many social groups (Slater and Kwami 2005). For the NMS, poverty risk is not found to be relevant in explaining the Internet usage.

At the level of EU-27 and NMS, the increase in unemployment is found to stimulate the Internet usage. One explanation is that unemployed people use the Internet to search for jobs (Kuhn and Skuterud 2004; Stevenson 2009) and also they have more time to use the Internet for personal purposes, in comparison with employed people. Moreover, unemployed people might take advantage of the Internet's lower prices (Fulgoni 2011). In the OMS, the unemployment is not found to be relevant in explaining the Internet use.

According to our findings, tertiary education enhances the Internet usage only in the OMS. Especially in the EU developed countries, the university graduates also need ICT skills to keep up with the demands of the digital economy (European Commission 2014, 2016). On the other hand, students generally acquire basic ICT skills during their studies, and after graduation they get even advanced computer skills (Kubey et al. 2001; Li and Kirkup 2007). In contrast, in the NMS this variable is not significant, meaning that here there are many jobs for university graduates that do not necessarily request ICT skills.

Secondary education is a significant determinant of Internet use only at the EU-27 level. Even that pupils are asked to develop their basic digital skills at school (Valcke et al. 2010), they will not develop and use these skills over the lifetime since the jobs available with a secondary education degree do not request ICT skills. This finding is therefore according to the strand of literature arguing that people with secondary educational attainments have less computer skills and tend to use less the Internet benefits (Volman et al. 2005).

A higher number of pupils in education is correlated with a lower Internet usage, and this variable is significant only at the EU-27 level. The literature also reports that pupils tend to use the Internet less than adults. This is because adults limit the use of Internet by their children in order to avoid the Internet addiction (Weinstein and Lejoyeux 2010). However, the interpretation of this result should be done in the context of the reference period of our study (2001–2016).

The number of physicians or doctors per 100.000 inhabitants carry significant but different effects on the Internet use for the EU-27 and OMS. In the OMS, the general population and especially professionals with a university degree, like doctors, have ICT skills and broadly utilize them in their current activity (Jadad et al. 2001). In order to keep up with the newest advances in the medical science, doctors should continuously develop their ICT skills (Chew et al. 2004).

In Table 4, the employment in HT sectors in the previous year is positively associated with its level in the current year. This autoregressive behaviour is consistent across all our three measures of digital economy (Tables 2, 3, 4).

However, for both the OMS and NMS the most powerful determinant is GDP per capita. In all models reported in Table 4, the effect of GDP per capita on the employment in HT sectors is positive, while the effect of its first lag is negative. This finding is according to our expectation since the HT sectors develop especially in regions that provide comparative locational advantages for technology companies. For instance, in the literature, technological districts and large urban areas are significantly associated with the probability of firms being high-growing technology firms (Giner et al. 2017). It is also found that the greater the geographic proximity of a company to urban centres, the greater their capacity to innovate (Ferreira et al. 2017). Moreover, the HT sectors develop in ecosystems with various actors and players, and require an adequate regulatory environment (Kearny 2014). All these aspects indicate that a more developed region is more likely to be successful in enhancing the development of HT sectors, and to therefore stimulate employment in

this sector. The effect is even larger for the NMS, where the poorest regions have no the appropriate infrastructure to attract HT companies, so that finally most HT sectors grow in developed regions.

Only in the OMS, a higher fertility is associated with a lower employment in HT sectors.

Upon our knowledge this relationship has not been examined in the literature, and nevertheless empirical findings on the relationship between fertility and economic performances are mixed. However EU studies indicate that women with low educational attainments had a higher fertility rate in the last ten years (Lanzieri 2013), and also that education in general and knowledge centres (e.g. universities) in particular play a fundamental role in shaping and enabling the evolution and growth of the EU's high-technology clusters (Keeble 1989; Agrawal and Cockburg 2003; Keeble and Wilkinson 2018). These dynamics could explain the negative relationship between fertility and employment in HT sectors in the OMS.

Numerous studies have shown that scientific universities play a fundamental role in stimulating the development of new technology based companies in their region (e.g. Segal 1995; Agrawal and Cockburg 2003). More recently, according to the New Skills Agenda for European Commission (2016), the employment in HT sectors requests high-tech skills, specialised skills, digital skills, key-enabling technologies skills, as well as leadership capabilities, which are provided by knowledge centres/universities. In this light, our finding that increasing the tertiary educational attainments results in a higher employment in HT sectors, is in line with the literature. Moreover, our estimates indicate that the positive effect will occur with a lag of 4 years.

In turn, as shown in Table 4, increasing the secondary educational attainments carries a small negative effect on the employment in HT sectors, but this effect is only slightly significant and just for the OMS. This result is not surprising since employment in HT sectors requires high level skills (as underlined before), so that a higher proportion of population with secondary educational attainments finally means a lower proportion of population having high technology skills.

In all 3 models reported in Table 4, a higher number of doctors in a region is found to have a positive impact on the employment in HT sectors. A large strand of literature on the interdependency between regional development and formation of technology clusters (Keeble and Gould 1985; Keeble 1989) confirms our empirical finding. At the regional level, the environmental conditions enabling a high quality of life, which are reflected *inter alia* by the access to healthcare services (proxied here by the number of doctors) facilitate the setting up and development of HT firms and sectors.

In contrast with the models reported in Tables 2 and 3, the poverty risk is not found to be a significant driver of the employment in HT sectors, which suggest that the HT sectors are rather affected by factors strongly related to the business ecosystem, and to a lesser extent by community-level social equilibrium.

The positive impact of the number of patents on employment in HT sector is a consistent result across all three models shown in Table 4. This result could be also framed in the literature. Patents are generally issued by the research-intensive universities as a result of their technology transfer experience. The co-location of university research and industrial R&D within the regional innovation system (Agrawal and Cockburg 2003), which is a key driver of the development of HT sectors, has been discussed so far.

5 Discussion and conclusions

Accelerating the growth of digital economy in the EU-27 regions by a set of consistent policy measures across several indicators of digital economy, as well as across the NMS, OMS and EU groups of countries, represents a major challenge for EU policy makers on the path of the Single Digital Market. To achieve this goal as well as to facilitate a better understanding of the regional patterns of this process, the EU digital economy must be also examined by its common and specific regional drivers. But digital economy is a broad umbrella covering different aspects related to the efficient incorporation of ICT and digital technologies into the economic activities. It has various dimensions and facets, so that analysing digital economy requests *inter alia* examining a set of underlying indicators. These indicators are operationalised here by regional level- variables which are provided by cross-country datasets, such as Eurostat.

Our paper examines a set of common and specific drivers of three indicators of digital economy, based on the Eurostat panel data. In subsidiary, this empirical approach allows us analysing the effectiveness of a set of policy measures aimed to accelerate the development of the EU digital economy and of the Single Digital Market, at regional level. Moreover, by comparing the effects of a set of determinants on three different indicators of digital economy and across three different groups of countries (EU-27, NMS and OMS), the paper allows identifying the eventual negative side effects of policy measures aimed to target the regional digital economy. Given that in the previous section our empirical results are confronted to previous findings in the literature, our new contributions are clearly highlighted throughout the empirical section.

The main results derived from the empirical analysis can be summarize as follows. First, we identify a common set of “effective” policy measures that stimulates the development of the EU regional digital economy, as defined by our three indicators. The regional economic development is found to be the main engine of the EU regional digital economy, especially at the NMS and EU-27 levels. Increasing the tertiary education attainments results in stimulating the development of the OMS regional digital economy, while the increase in the secondary education attainments (ISCED levels 2 and 3) hinder it. The number of patents issued at regional level, as an indicator of R&D output, represents a significant driver of digital economy, while a higher rate of poverty discourages the growth of digital economy, especially in the OMS.

Second, our data lead us to identify another set of policy measures whose effects are contrasting across countries and measures, like increasing the number of doctors, stimulating the population growth and fertility, as well as increasing the proportion of population with secondary education attainments. This suggest that the policy measures which are elaborated based on these contrasting results should be applied with precaution within the EU-27.

Among the policy measures derived from the empirical analysis, only a small set of them could enhance the development of the regional digital economy without producing negative side effects, not across indicators, and nor across groups of countries. These policy measures, which are the increase in the tertiary education attainments and the stimulation of patents development, are found to be the most effective ones, according to our data and variables. They should be primary implemented within the EU.

The managerial implications of the above policy measures for the EU governments could be synthesized as follows. Firstly, the development of digital economy should be approached at regional level as well, not only at the country level, and this objective

could be met especially by regional achievements in higher education and R&D. This requests supporting the regional balanced development of digital economy by empowering local regional stakeholders from education and R&D. Second, the regional digital economy is found to be significantly enhanced by the regional economic development, so that it should emerge from the regional digital growth strategies and ICT innovation priorities, which themselves are grounded in the specific economic, social and demographic regional context. Third, given that the policy measures could generate slightly different effects on NMS and OMS, policies in education should be elaborated in the national and local frameworks, and to a lesser extent at the EU centralized level. However, local/regional and state authorities should collaborate and support together the regional balanced development of digital economy.

Like any research study, this one has its own limitations, which mainly derive from the data availability. Even though the concept of digital economy could be operationalized by many other indicators than we use here, the lack of comparable panel and regional data/variables restrains its area of definition and analysis. Compared to a cross-country study, the regional perspective of this analysis is constrained by a lower availability of variables in the Eurostat dataset. Nevertheless, given the rapid advances in ICT and HT sector, the panel datasets are rather short because of new indicators/variables which often occur to capture new dimensions of the digital transformation. This induces a number of difficulties and challenges in the methodological part.

In conclusion, stimulating the growth of digital economy in the EU regions represents a complex task for the EU policy makers, which requests addressing different dimensions/indicators of this composite measure through a set of effective policies. To be effective, the policy measures need to improve each indicator of digital economy, without worsening the others. Previous papers have shown that most policy measures produce contrasting effects when targeting different dimensions or indicators, so that finding an effective mix of policies designed as to improve a multidimensional measure, such as it is here the digital economy, could be a very difficult task (Raileanu Szeles 2015, 2018).

The contribution of our paper to the literature is threefold. First, it develops a regional analysis of the EU digital economy, focusing on the regional drivers that are relevant for a set of policy measures at country- and EU levels. As also stated in Introduction, upon our knowledge, the regional digital economy has not been approached by research papers so far. Examining the regional digital economy could bring additional empirical insights to the literature. For example, when moving the analysis from the country level to the regional level, the impact of some drivers could be different, such as the influence of regional economic development in the OMS. Therefore, drawing a regional picture of the EU digital economy enriches the global overview. Second, it introduces new social and demographic variables into the analysis of the regional digital economy, such as the number of doctors and fertility rate. This attempt provides additional empirical evidence to the existing literature. Third, it examines whether a set of policy measures aimed to accelerate the growth of regional digital economy also produces negative side effects across different measures of regional economy or different groups of EU countries. Finally, our empirical approach is intended to help EU policy makers to stimulate the EU regional digital economy through a set of effective policy measures.

Appendix

See Table 5.

Table 5 Testing for multicollinearity Variance inflation factors

Independent variables	Electronic commerce	Internet usage	Employment in HT sectors
Log GDP per capita	5.15	3.80	2.97
Fertility	2.66	1.74	1.72
Doctors	1.82	1.55	1.62
Poverty risk	2.19	2.26	2.12
Tertiary education	3.09	2.09	1.82
Secondary education	3.16	1.59	1.24
Patents	1.41	–	1.37
Pupils	1.41	1.83	–
Life expectancy	5.41	–	–
Unemployment	2.16	1.86	–

References

- Acs, Z. J., Fitzroy, F. R., & Smith, I. (1999). High technology employment, wages and university R&D spillovers: Evidence from US cities. *Economics of Innovation and New Technology*, 8(1–2), 57–78.
- Agrawal, A., & Cockburg, I. (2003). The anchor tenant hypothesis: Exploring the role of large, local, R&D-intensive firms in regional innovation systems. *International Journal of Industrial Organization*, 21(9), 1227–1253.
- Al-Qirim, N. A. (2004). A framework for electronic commerce research in small to medium-sized enterprises. In N. A. Al-Qirim (Ed.), *Electronic commerce in small to medium-sized enterprise: Frameworks, issue and implications*. Hershey: IGI Global.
- Al-Qirim, N. A. (2007). The adoption of eCommerce communications and applications technologies in small businesses in New Zealand. *Electronic Commerce Research and Applications*, 6(4), 462–473.
- Anton, C. (2010). Considerations on the contract relations between the financial–accounting services companies of Romania and their clients. In *INTED2010 proceedings* (pp. 1182–1193).
- Anvari, R. D., & Norouzi, D. (2016). The impact of E-commerce and R&D on economic development in some selected countries. *Procedia—Social and Behavioral Sciences*, 229, 354–362.
- Armstrong, L., Phillips, J. G., & Saling, L. L. (2000). Potential determinants of heavier internet usage. *International Journal of Human–Computer Studies*, 53(4), 537–550.
- Arnum, E., & Conti, S. (1998). Internet deployment worldwide: The new superhighway follows the old wires, rails, and roads. In *Inet* (Vol. 98, pp. 21–24).
- Baltagi, B. H. (2014). *Econometric analysis of panel data*. Chichester: Wiley.
- Baum, C. F., Schaffer, M. E., & Stillman, S. (2003). Instrumental variables and GMM: Estimation and testing. *The Stata Journal*, 3(1), 1–31.
- Bazar, B., & Boalch, G. (1997). A preliminary model of internet diffusion within developing countries. In *AusWeb97 third Australian world wide web conference* (Vol. 5, No. 9).
- Beck, U. (2000). The cosmopolitan perspective: Sociology of the second age of modernity. *The British journal of sociology*, 51(1), 79–105.
- Beck, R., Wigand, R. T., & König, W. (2005a). Integration of e-commerce by SMEs in the manufacturing sector: A data envelopment analysis approach. *Journal of Global Information Management (JGIM)*, 13(3), 20–32.
- Beck, R., Wigand, R. T., & König, W. (2005b). The diffusion and efficient use of electronic commerce among small and medium-sized enterprises: An international three-industry survey. *Electronic Markets*, 15(1), 38–52.

- Beilock, R., & Dimitrova, D. V. (2003). An exploratory model of inter-country Internet diffusion. *Tel-ecomunications Policy*, 27(3–4), 237–252.
- Billari, F., Giuntella, O., & Stella, L. (2019). Does broadband internet affect fertility? *Journal of Population Studies*, 73(3), 297–316.
- Billon, M., Crespo, J., & Lera-López, F. (2017). Internet, educational disparities, and economic growth: Differences between low-middle and high-income countries. In H. Kaur, E. Lechman, & A. Marszk (Eds.), *Catalyzing development through ICT adoption* (pp. 51–68). Cham: Springer.
- Blank, G., & Groselj, D. (2014). Dimensions of internet use: Amount, variety, and types. *Information, Communication & Society*, 17(4), 417–435.
- Büchi, M., Just, N., & Latzer, M. (2016). Modeling the second-level digital divide: A five-country study of social differences in Internet use. *New Media & Society*, 18(11), 2703–2722.
- Burke, K. (2005). The impact of firm size on internet use in small businesses. *Electronic Markets*, 15(2), 79–93.
- Campos, R., Arrazola, M., & de Hevia, J. (2017). Economic crisis and benefits of the internet: differentiated Internet usage by employment status. *Economics of Innovation and New Technology*, 26(3), 269–294.
- Caniëls, M. C., Lenaerts, H. K., & Gelderman, C. J. (2015). Explaining the internet usage of SMEs: The impact of market orientation, behavioural norms, motivation and technology acceptance. *Internet Research*, 25(3), 358–377.
- Carson, D. (1993). A philosophy for marketing education in small firms. *Journal of Marketing Management*, 9(2), 189–204.
- Carstensen, L. L. (1995). Evidence for a life-span theory of socioemotional selectivity. *Current Directions in Psychological Science*, 4(5), 151–156.
- Celuch, K., Murphy, G. B., & Callaway, S. K. (2007). More bang for your buck: Small firms and the importance of aligned information technology capabilities and strategic flexibility. *The Journal of High Technology Management Research*, 17(2), 187–197.
- Charles, S. T., & Carstensen, L. L. (1999). The role of time in the setting of social goals across the life span. In F. Blanchard-Fields & T. Hess (Eds.), *Social cognition and aging* (pp. 319–342). New York: Academic Press.
- Chew, F., Grant, W., & Tote, R. (2004). Doctors on-line: Using diffusion of innovations theory to understand internet use. *Family Medicine-Kansas City*, 36, 645–650.
- Chong, S. (2008). Success in electronic commerce implementation. *Journal of Enterprise Information Management*, 21(5), 468–492.
- Choshin, M., & Ghaffari, A. (2017). An investigation of the impact of effective factors on the success of e-commerce in small- and medium-sized companies. *Computers in Human behaviour*, 66, 67–74.
- Cruz-Jesus, F., Vicente, M. R., Bacao, F., & Oliveira, T. (2016). The education-related digital divide: An analysis for the EU-28. *Computers in Human Behavior*, 56, 72–82.
- Czaja, S. J. (2016). Long-term care services and support systems for older adults: The role of technology. *American Psychologist*, 71(4), 294–301.
- Day, G. S. (1994). Continuous learning about markets. *California Management Review*, 36(4), 9–31.
- ***Digital Economy Report, United Nations, Geneva (2019).
- Dimitrova, D. V. (2002). Internet diffusion in the post-communist countries. *Medienjournal: Innovative Approaches to ICT. Research*, 26(3), 64–71.
- Dimitrova, D. V., & Beilock, R. (2005). Where freedom matters: Internet adoption among the former socialist countries. *Gazette (Leiden, Netherlands)*, 67(2), 173–187.
- Dimitrova, D. V., Kaid, L. L., Williams, A. P., & Trammell, K. D. (2005). War on the web: The immediate news framing of Gulf War II. *Harvard International Journal of Press/Politics*, 10(1), 22–44.
- Dimitrova, N., Li, D., Sethi, I. K., & McGee, T. (2001). Classification of general audio data for content-based retrieval. *Pattern Recognition Letters*, 22(5), 533–544.
- Drukker, D. M. (2003). Testing for serial correlation in linear panel-data models. *Stata Journal*, 3, 168–177.
- Drumea, C. (2015). Analysis of the cost impact of the new technologies in e-tail. *Bulletin of the Transilvania University of Brasov (Economic Sciences)*, 8(1), 159–168.
- Duguleana, C., Duguleana, L., & Busuioceanu, S. (2017). Identifying the effects of migration flows within the countries of the European union. In N. Marinescu (Ed.), *East–west migration in the European Union*. Cambridge: Cambridge Scholars Publishing.
- Dulloo, R., & Rajeswari, M. (2018). Retail mobility in India's digital age: Exploring determinants of its adoption. *International Journal of Pure and Applied Mathematics*, 120(6), 10543–10563.
- Elie, M. (1998). *The internet and global development*. In Proceedings of INET98 (Geneva, Switzerland, July 21–24). Reston, VA: Internet Society.

- Ertürk, A., & Vurgun, L. (2015). Retention of IT professionals: Examining the influence of empowerment, social exchange, and trust. *Journal of Business Research*, 68(1), 34–46.
- European Commission. (2014). *Digital Agenda for Europe*. Brussels: European Commission.
- European Commission. (2016). *A new skills agenda for Europe: Working together to strengthen human capital, employability and competitiveness*. Retrieved February 28, 2018 from http://ec.europa.eu/growth/content/new-skills-agenda-blueprint-cooperation-skills-1_en.
- Expert Panel on effective ways of investing in Health (EXPH) Report on Access to Health Services in the European Union, 3 May 2016.
- Fathian, M., Akhavan, P., & Hoorali, M. (2008). E-readiness assessment of non-profit ICT SMEs in a developing country: The case of Iran. *Technovation*, 28(9), 578–590.
- Ferreira, J. J. M., Fernandes, C. I., & Raposo, M. L. (2017). The effects of location on firm innovation capacity. *Journal of the Knowledge Economy*, 8(1), 77–96.
- Fink, D., & Disterer, G. (2006). International case studies: To what extent is ICT infused into the operations of SMEs? *Journal of Enterprise Information Management*, 19(6), 608–624.
- Finlay, J. (2007). *The role of health in economic development*. Harvard Initiative for Global Health. PGDA working paper, 21.
- Fisher, J., Craig, A., & Bentley, J. (2007). Moving from a web presence to e-commerce: The importance of a business—web strategy for small-business owners. *Electronic Markets*, 17(4), 253–262.
- Friemel, T. (2016). The digital divide has grown old: Determinants of a digital divide among seniors. *New Media and Society*, 18(2), 313–331.
- Fulgoni, J. G. (2011). Webinar series: State of the U.S. Online Retail Economy through Q1 2011.
- García, P., Thapa, B., & Niehaves, B. (2014). Bridging the digital divide at the regional level? The effect of regional and national policies on broadband access in Europe's Regions. In M. Janssen, H. J. Scholl, M. A. Wimmer, & F. Bannister (Eds.), *Electronic government. EGOV 2014. Lecture notes in computer science* (Vol. 8653). Berlin: Springer.
- Giner, J. M., Santa-María, M. J., & Fuster, A. (2016). High-growth firms: Does location matter? *International Entrepreneurship and Management Journal*, 13(1), 75–96.
- Goss, E. P., & Phillips, J. M. (2002). How information technology affects wages: Evidence using internet usage as a proxy for IT skills. *Journal of Labour Research*, 3(23), 463–474.
- Grandon, E. E., & Pearson, J. M. (2004). Electronic commerce adoption: An empirical study of small and medium US businesses. *Information & Management*, 42(1), 197–216.
- Guillén, M. F., & Suárez, S. L. (2001). Developing the internet: entrepreneurship and public policy in Ireland, Singapore, Argentina, and Spain. *Telecommunications Policy*, 25(5), 349–371.
- Guillén, M. F., & Suárez, S. L. (2005). Explaining the global digital divide: Economic, political and sociological drivers of cross-national Internet use. *Social Forces*, 84(2), 681–708.
- Hair, J. F., Jr., Anderson, R. E., Tatham, R. L., & Black, W. C. (1995). *Multivariate data analysis* (3rd ed.). New York: Macmillan.
- Hamburger, Y. A., & Ben-Artzi, E. (2000). The relationship between extraversion and neuroticism and the different uses of the Internet. *Computers in Human Behavior*, 16(4), 441–449.
- Hanna, N. (2016). *Mastering digital transformation*. Emerald: UK.
- Hanna, N. K., & Knight, P. T. (2012). *National strategies to harness information technology, innovation, technology and knowledge management*. New York: Springer.
- Hargittai, E. (1999). Weaving the western web: Explaining differences in internet connectivity among OECD countries. *Telecommunications Policy*, 23(10–11), 701–718.
- Hayashi, F. (2000). *Econometrics* (Vol. 1, pp. 60–69). Princeton University Press: Princeton.
- Helsper, E. J. (2010). Gendered internet use across generations and life stages. *Communication Research*, 37(3), 352–374.
- Holm, J. R., & Østergaard, C. R. (2015). Regional employment growth, shocks and regional industrial resilience: A quantitative analysis of the Danish ICT sector. *Regional Studies*, 49(1), 95–112.
- Hong, J. P. (2017). Causal relationship between ICT R&D investment and economic growth in Korea. *Technological Forecasting and Social Change*, 116, 70–75.
- International Monetary Fund. (2018). *Measuring the digital economy*. IMF Policy Papers.
- Jadad, A. R., Sigouin, C., Cocking, L., Booker, L., Whelan, T., & Browman, G. (2001). Internet use among physicians, nurses, and their patients. *JAMA*, 286(12), 1451–1452.
- Jeon, B. N., Han, K. S., & Lee, M. J. (2006). Determining factors for the adoption of e-business: The case of SMEs in Korea. *Applied Economics*, 38(16), 1905–1916.
- Kartiwi, M., & MacGregor, R. C. (2007). Electronic commerce adoption barriers in small to medium-sized enterprises (SMEs) in developed and developing countries: A cross-country comparison. *Journal of Electronic Commerce in Organizations (JEKO)*, 5(3), 35–51.

- Kasiri, L. A., Cheng, K. T. G., Sambasivan, M., & Sidin, S. M. (2017). Integration of standardization and customization: Impact on service quality, customer satisfaction, and loyalty. *Journal of Retailing and Consumer Services*, 35, 91–97.
- Kearny, A.T. (2014). *Rebooting Europe's high-tech industry*. Research report on: <https://www.atkearney.com/documents/10192/7828589/Rebooting+Europes+HighTech+Industry.pdf/531ff9a7-3bba-4274-8ce7-d4b20b71d508>. Retrieved January 30, 2018.
- Keeble, D. (1989). High-technology industry and regional development in Britain: the case of the Cambridge phenomenon. *Environment and Planning C: Government and Policy*, 7, 153–172.
- Keeble, D., & Gould, A. (1985). Entrepreneurship and manufacturing firm formation in rural regions: The East Anglian case. In M. J. Healey & B. W. Ilberg (Eds.), *The industrialization of the countryside* (pp. 197–220). Norwich: Geo Books.
- Keeble, D., & Wilkinson, F. (2018). High-technology SMEs, regional clustering and collective learning: An overview. In D. Keeble & F. Wilkinson (Eds.), *High-technology clusters, networking and collective learning in Europe* (pp. 1–21). New York: Routledge.
- Kotarba, M. (2018). Digital transformation of business models. *Foundations of Management*, 10, 123–142.
- Kubey, R. W., Lavin, M. J., & Barrows, J. R. (2001). Internet use and collegiate academic performance decrements: Early findings. *Journal of Communication*, 51(2), 366–382.
- Kuhn, P., & Skuterud, M. (2004). Internet job search and unemployment durations. *American Economic Review*, 94(1), 218–232.
- Kula, V., & Tatoglu, E. (2003). An exploratory study of Internet adoption by SMEs in an emerging market economy. *European Business Review*, 15(5), 324–333.
- Kumar, V., Arif, T., & Malik, M. (2014). *Role of ICT in driving e-commerce business in developing countries*. Paper presented at the conference: National conference on recent innovations and advancements in information technology-RIAIT'2014.
- Landers, R. N., & Lounsbury, J. W. (2006). An investigation of Big Five and narrow personality traits in relation to Internet usage. *Computers in Human Behavior*, 22(2), 283–293.
- Lanzieri, G. (2013). Towards a “baby recession” in Europe. *Eurostat Statistics in Focus*, 13, 16–539.
- Lawson, R., Alcock, C., Cooper, J., & Burgess, L. (2003). Factors affecting adoption of electronic commerce technologies by SMEs: An Australian study. *Journal of Small Business and Enterprise Development*, 10(3), 265–276.
- Leung, L. (2002). Loneliness, self-disclosure, and ICQ (“I seek you”) use. *CyberPsychology & Behavior*, 5(3), 241–251.
- Li, N., & Kirkup, G. (2007). Gender and cultural differences in Internet use: A study of China and the UK. *Computers & Education*, 48(2), 301–317.
- Litră, A. (2014). Economic effects of demographic ageing. *Bulletin of the Transilvania University of Brasov*, 7(56), 229–234.
- Lund, M. J. F., & McGuire, S. (2005). Institutions and development: Electronic commerce and economic growth. *Organization Studies*, 26(12), 1743–1763.
- Macchi, M., Berthon, B., & Robinson, M. (2015). Digital density index-guiding digital transformation. New York. Retrieved January 10, 2018 from <https://www.scribd.com/document/377691886/Accenture-Digital-Density-Index-Guiding-Digital-Transformation>.
- Maherzi, L. (1997). *World communication report: The media and the challenge of the new technologies*. Unesco.
- Margaras, V. (2018). *The regions in the digital single market*. Brussels: Briefing, European Parliament Research Service.
- Mendoza, M. R. H., & Alvarez de Toledo, J. A. (1997). Demographics and behavior of the Chilean internet population. *Journal of Computer-Mediated Communication*, 3(1), JCMC315.
- Merton, R. K. (1957). Patterns of influence: Local and cosmopolitan influentials. *Social Theory and Social Structure*, 2, 387–420.
- Migiro, S. O. (2006). Diffusion of ICTs and E-commerce adoption in manufacturing SMEs in Kenya. *South African Journal of Libraries and Information Science*, 72(1), 35–44.
- Mohamad, R., & Ismail, N. A. (2009). Electronic commerce adoption in SME: The trend of prior studies. *Journal of Internet Banking and Commerce*, 14, 1.
- Molla, A., & Licker, P. S. (2005). Perceived e-readiness factors in e-commerce adoption: An empirical investigation in a developing country. *International Journal of Electronic Commerce*, 10(1), 83–110.
- Narver, J. C., & Slater, S. F. (1990). The effect of a market orientation on business profitability. *The Journal of Marketing*, 54, 20–35.
- Nelson, R. R. (Ed.). (1993). *National innovation systems*. New York: Oxford University Press.

- Niebel, T. (2018). ICT and economic growth—Comparing developing, emerging and developed countries. *World Development*, *104*, 197–211.
- NTIA. (1999). Falling through the net: Defining the digital divide. Retrieved January 30, 2018 from <http://www.infodiv.org/library/WorkingPapers/wilsonrodriguez.doc>.
- Olphert, W., & Damodaran, L. (2013). Older people and digital disengagement: A fourth digital divide? *Gerontology*, *59*, 564–570.
- Oostrom, L., Walker, A., Staats, B., Slootbeek-Van Laar, M., Azurduy, S., & Rooijakkers, B. (2016). *Measuring the internet economy in the Netherlands: A big data analysis*. CBS Discussion paper, 14.
- Pappas, I. O., Kourouthanassis, P. E., Giannakos, M. N., & Lekakos, G. (2017). The interplay of online shopping motivations and experiential factors on personalized e-commerce: A complexity theory approach. *Telematics and Informatics*, *34*(5), 730–742.
- Peek, S. T., et al. (2016). Older adults' reasons for using technology while aging in place. *Gerontology*, *62*, 226–237.
- Pick, J. B., & Nishida, T. (2015). Digital divides in the world and its regions: A spatial and multivariate analysis of technological utilization. *Technological Forecasting and Social Change*, *91*, 1–17.
- Piva, M., & Vivarelli, M. (2017). Technological change and employment: Were Ricardo and Marx Right?
- Porter, C. E., & Donthu, N. (2006). Using the technology acceptance model to explain how attitudes determine Internet usage: The role of perceived access barriers and demographics. *Journal of Business Research*, *59*(9), 999–1007.
- Press, L., Burkhart, G., Foster, W., Goodman, S., Wolcott, P., & Woodard, J. (1998). An internet diffusion framework. *Communications of the ACM*, *41*(10), 21–26.
- Răileanu Szeles, M. (2015). Explaining the dynamics and drivers of financial well-being in the European Union. *Social Indicators Research*, *120*(3), 701–722.
- Răileanu Szeles, M. (2018). New insights from a multilevel approach to the regional digital divide in the European Union. *Telecommunications Policy*, *42*(6), 452–463.
- Ramayah, T., Yan, L. C., & Sulaiman, M. (2005). SME e-readiness in Malaysia: Implications for planning and implementation. *Sasin Journal of Management*, *11*(1), 103–120.
- Raven, P. V., Huang, X., & Kim, B. B. (2007). E-business in developing countries: A comparison of China and India. *International Journal of E-Business Research (IJEER)*, *3*(1), 91–108.
- Raymond, L., Bergeron, F., & Blili, S. (2005). The assimilation of E-business in manufacturing SMEs: Determinants and effects on growth and internationalization. *Electronic Markets*, *15*(2), 106–118.
- Robles, J. M., Torres-Albero, C., & de Marco, S. (2011). Spanish E-government and the third digital divide: A sociological view. *Journal of US-China Public Administration*, *8*(4), 401–412.
- Rogers, E. M. (2010). *Diffusion of innovations*. New York: Simon and Schuster.
- Safavi, R. (2009). *Human/social factors influencing usability of E-commerce websites and systems*. In Conference paper, conference “Application of information and communication technologies”, AICT.
- Saidi, K., Mbarek, M. B., & Amamri, M. (2018). Causal dynamics between energy consumption, ICT, FDI, and economic growth: Case study of 13 MENA countries. *Journal of the Knowledge Economy*, *9*, 228–238.
- Sealy, M., Phillips, J. G., & Stevenson, R. (2002). Shyness and anxiety as predictors of patterns of internet usage. *CyberPsychology & Behavior*, *5*(6), 507–515.
- Scheerder, A., van Deursen, A., & van Dijk, J. (2017). Determinants of Internet skills, uses and outcomes. A systematic review of the second-and third-level digital divide. *Telematics and Informatics*, *34*, 1607–1624.
- Schmitz, H. (2018). *Technology and employment practices in developing countries* (Vol. 47). Abingdon: Routledge.
- Schultz, R. A. (Ed.). (2005). *Contemporary issues in ethics and information technology*. Hershey: IGI Global.
- Segal, B. (1995). *A short history of Internet protocols at CERN*. Professional webpage. April. <http://ben.home.cern.ch/ben/TCPHIST.html>.
- Seyal, A. H., Awais, M. M., Shamail, S., & Abbas, A. (2004). Determinants of electronic commerce in Pakistan: Preliminary evidence from small and medium enterprises. *Electronic Markets*, *14*(4), 372–387.
- Sharma, S. K., Ahmed, N., & Wickramasinghe, N. (2004). E-commerce adoption in small and medium enterprises (SMEs) in Asia: A study of the early stages of e-commerce uptake. *International Journal of Internet and Enterprise Management*, *2*(3), 221–240.
- Slater, D., & Kwami, J. (2005). *Embeddedness and escape: Internet and mobile use as poverty reduction strategies in Ghana*. Information Society Research Group (ISRG) report.
- Song, Z., Sun, Y., Wan, J., Huang, L., & Zhu, J. (2017). Smart e-commerce systems: Current status and research challenges. *Electronic Markets*, *29*, 1–18.

- Stanley, T. D., Doucouliagos, H., & Steel, P. (2018). Does ICT generate economic growth? A meta-regression analysis. *Journal of Economic Surveys*, 32(3), 705–726.
- Stevenson, B. (2009). The internet and job search. In H. A. David (Ed.), *Studies of labor market intermediation* (pp. 67–86). Chicago: University of Chicago Press.
- Tapscott, D. (1997). *The digital economy: Promise and peril in the age of networked intelligence*. New York, USA: McGrawHill.
- Teo, T. S., & Pian, Y. (2003). A contingency perspective on Internet adoption and competitive advantage. *European Journal of Information Systems*, 12(2), 78–92.
- Thong, J. Y. (2001). Resource constraints and information systems implementation in Singaporean small businesses. *Omega*, 29(2), 143–156.
- UNCTAD. (2019). *Digital economy report 2019: Value creation and capture—Implications for developing countries*. Geneva.
- United Nations. (2005). *Core ICT indicators*. Beirut: United Nations.
- Valcke, M., Bonte, S., De Wever, B., & Rots, I. (2010). Internet parenting styles and the impact on Internet use of primary school children. *Computers & Education*, 55(2), 454–464.
- Van Deursen, A. J., Courtois, C., & van Dijk, J. A. (2014). Internet skills, sources of support, and benefiting from internet use. *International Journal of Human–Computer Interaction*, 30(4), 278–290.
- Van Dijk, J., & Hacker, K. (2003). The digital divide as a complex and dynamic phenomenon. *Information Society*, 19, 315–326.
- Vicente, M. R., & López, A. J. (2011). Assessing the regional digital divide across the European Union-27. *Telecommunications Policy*, 35, 220–237.
- Volman, M., Van Eck, E., Heemskerk, I., & Kuiper, E. (2005). New technologies, new differences. Gender and ethnic differences in pupils' use of ICT in primary and secondary education. *Computers & Education*, 45(1), 35–55.
- Wang, X., & Liu, L. (2015). Empirical research on the influence factors of e-commerce development in China. *The Open Cybernetics and Systemics Journal*, 9, 76–82.
- Weinstein, A., & Lejoyeux, M. (2010). Internet addiction or excessive internet use. *The American Journal of Drug and Alcohol Abuse*, 36(5), 277–283.
- Wolcott, P., Press, L., McHenry, W., Goodman, S. E., & Foster, W. (2001). A framework for assessing the global diffusion of the Internet. *Journal of the Association for Information Systems*, 2(1), 1–53.
- Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. Cambridge: MIT Press.
- Wunnava, P. V., & Leiter, D. B. (2009). Determinants of intercountry internet diffusion rates. *The American Journal of Economics and Sociology*, 68(2), 413–426.
- Zotta, C., Amitb, R., & Donlevya, J. (2000). Strategies for value creation in e-commerce: Best practice in Europe. *European Management Journal*, 18(5), 463–475.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.